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Original Article

Pediatric ankle injuries in United States emergency departments: A 10-Year national analysis

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Abstract

Objective: To describe national emergency department (ED) burden, diagnoses, and temporal patterns of pediatric ankle injuries and to explore rule-based mechanisms and activity classifications from 2016 to 2025.

Methods: We analyzed 2016-2025 Consumer Product Safety Commission National Electronic Injury Surveillance System records for patients aged < 18 years with ankle as the primary injured body part (code 37). National estimates used case weights and approximate Taylor 95% confidence intervals (CIs). Rule-based narrative and product-label classifications were prespecified, exploratory, and not manually validated. A 2019-2025 sensitivity analysis included either injury slot.

Results: The sample contained 79,245 cases, representing 2,468,384 ED-treated injuries (95% CI, 2,283,776-2,652,992), or 246,838 annually. Patients aged 10-14 years accounted for 44.5% and those aged 15-17 years for 35.7%; 51.8% were male. Sprains/strains predominated (68.6%), followed by fractures (11.6%). An estimated 1.03% were transferred, admitted, or observed. Visits fell 44.1% from 2019 to 2020 and reached 1.7% above the 2019 estimate by 2025; full-period annual percentage change was -1.82% (95% CI, -5.95% to 2.50%; p = 0.354). Either-slot inclusion increased the 2019-2025 estimate by 5.9%.

Conclusion: Pediatric ankle injuries generated substantial ED-treated burden concentrated among adolescents and dominated by sprains/strains. Rule-based mechanisms and activity findings are hypothesis-generating and do not establish causal mechanisms, comparative risk, or preventive effectiveness.

Level of Evidence III; Retrospective Descriptive Epidemiological Study.

Keywords: Adolescent; Ankle injuries; Emergency service, Hospital; Pediatrics; Population surveillance.

Introduction

Ankle injuries are among the most common musculoskeletal injuries, particularly in younger and athletic populations[1-3]. National studies have shown that ankle sprains comprise a substantial proportion of lower-extremity emergency department (ED) visits and peak during adolescence[2,4]. Although sprains predominate, the ED population includes a broader clinical spectrum, including fractures, dislocations, contusions, lacerations, and nonspecific pain/injury. This distinction is important because fractures are represented more often in ED surveillance than in school athletic training settings, suggesting that the care setting shapes the observed case mix[3].

Study performed at the Touro College of Osteopathic Medicine, New York, NY, USA.

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Pediatric ankle injuries merit separate study because skeletal maturity, activity patterns, and injury consequences differ from those in adults. Ankle fracture patterns vary by age and mechanism, and pediatric physeal fractures may cause growth disturbance or articular incongruity[5,6]. Sports-related ankle injury research has identified basketball, football, and soccer as common contexts[2,7-10]; however, most prior national studies have focused on a single diagnosis, sport, or restricted age range. Recent National Electronic Injury Surveillance System (NEISS) studies have expanded comparisons across sports and body regions[11-13], yet a contemporary national analysis of the complete diagnostic spectrum of pediatric ankle injuries across all products and activities remains limited.

This study aimed to quantify the national burden of pediatric ankle injuries treated in United States EDs from 2016 to 2025 and to describe patient characteristics, diagnoses, injury locations, dispositions, and temporal trends. Prespecified rule-based analyses also explored mechanism and activity contexts. We hypothesized that ED-treated injuries would be concentrated among adolescents, sprains/strains would predominate, sports contexts would be commonly recorded, and the 2020 coronavirus disease 2019 (COVID-19) disruption would be followed by recovery in annual ED visits. Mechanism and activity classifications were considered hypothesis-generating rather than validated outcomes.

Methods

Data source and study design

This retrospective descriptive epidemiology study used publicly available, de-identified NEISS data maintained by the United States Consumer Product Safety Commission (CPSC). NEISS collects injury information from a stratified probability sample of United States hospitals with 24-hour EDs and supplies case weights for national estimation[14,15]. The analysis used only publicly available, de-identified records, and no patient contact occurred; therefore, institutional review board approval and informed consent were not required. Reporting followed the STROBE cross-sectional study checklist, version 4, which is submitted as supplementary material[16].

Annual NEISS files from January 1, 2016, to December 31, 2025, were combined. The primary cohort included patients aged < 18 years whose first recorded body-part code was ankle (code 37). The primary-slot definition preserved a consistent case definition across all study years. A second body-part and diagnosis slot became available in 2019; therefore, a prespecified 2019-2025 sensitivity cohort included ankle code 37 in either injury slot. Records coded only to the foot without ankle code 37 were not included. The study quantified the ED-treated burden; population incidence rates were not calculated because age-specific population denominators and exposure data were outside the supplied dataset.

The study period spanned the NEISS sample transition. CPSC resampled NEISS in 2021, collected data from the old and redesigned samples concurrently in 2024, and first used the redesigned hospital sample to calculate national estimates in 2024(23). We applied the case-level CPSC weights supplied in each annual public-use file. Estimates from 2016-2023 and 2024-2025 are therefore nationally weighted within their respective sample designs; however, comparisons crossing the 2023-2024 boundary should be interpreted cautiously.

Variables and classification

Demographic variables included age, sex, race, and, from 2019 onward, Hispanic ethnicity. Age was grouped as 0-4, 5-9, 10-14, and 15-17 years. Diagnoses were grouped as sprain/strain, fracture, other injury/pain, contusion/abrasion, laceration, dislocation, and other rare diagnoses using CPSC diagnosis codes[15]. ED disposition was categorized as treated/released, transferred, admitted/hospitalized, held for observation, left without being seen, fatality, or unknown. Escalated disposition was prespecified as transfer, admission, or observation. Injury locations, months, and seasons were analyzed from structured fields. Race and ethnicity were retained descriptively, with missingness reported. Hispanic ethnicity and companion injury fields were interpreted only for 2019-2025 because of field availability.

Three prespecified rule hierarchies generated exploratory classifications (Table 1). Mechanism was assigned from narrative text alone, with first-match priority for hazard, crush/entrapment, overuse/atraumatic, contact/direct blow, rotation/misstep, jump/landing, fall, and wheeled/traffic terms; records without a match were other/unclear. Activity was assigned from the combined narrative and CPSC text labels for all nonzero Product_1, Product_2, and Product_3 codes, again retaining the first match. Numeric product codes did not determine mechanism. Fracture subtype was assigned from narrative text only among records whose index diagnosis was fracture, with first-match priority for physeal, bi-/trimalleolar, distal fibula/lateral malleolus, distal tibia/medial malleolus, talus, and avulsion terms. These classifications were not manually validated and are presented as hypothesis-generating descriptive groupings.

For activity, common CPSC product-label mappings included basketball (1205), football (1211), trampoline (1233), volleyball (1266), soccer (1267), wrestling (1270), gymnastics (1272), skateboards (1333), cheerleading (3254), martial arts (3257), dancing (3278), track and field (5030), softball (5034), bicycles (5040), and baseball (5041). The full ordered keywords and product-label handling are reported in Table 1. Because narrative capacity expanded beyond 142 characters during the study interval, a sensitivity analysis repeated mechanism classification using only the first 142 characters of every narrative. Agreement from that analysis was interpreted only as sensitivity to text length and not as validation.

Statistical analysis

National totals were calculated as the sum of CPSC case weights. Weighted proportions used the primary cohort as

Table 1. Prespecified ordered rules for exploratory mechanism, activity, and fracture-subtype classification

Domain	Ordered category	Operational match terms	Fields searched
Mechanism	1. Penetrating/burn/ bite/other hazard	cut, lacerat*, puncture, stab, glass, nail, bite, sting, burn, scald, chemical, electric, or foreign body	Narrative only
Mechanism	2. Crush/ entrapment/struck by object	crush, caught, trapped, stuck, closed on, door, object fell, dropped … on, or equipment/stage/weight fell	Narrative only
Mechanism	3. Overuse/ atraumatic	overuse, repetitive, gradual, atraumatic, no known injury, denies trauma, without trauma, tendinitis, tendinopathy, stress fracture, apophysitis, Sever's, weeks of pain, or chronic	Narrative only
Mechanism	4. Contact/collision/ direct blow	collid*, collision, contact, tackl*, another player, opponent, teammate, person/player fell on, kicked/hit/struck by, stepped on … foot, landed on … foot, ran into, or smacked	Narrative only
Mechanism	5. Noncontact rotation/misstep	twist*, inversion, eversion, pivot, plant*, misstep, missed step, stepped wrong, turned ankle, or rolled/rolling within 24 characters of ankle or foot	Narrative only
Mechanism	6. Jump/landing	jump*, landing, landed, came down, dismount, leap, or leapt	Narrative only
Mechanism	7. Fall	fall, fell, fallen, trip*, slip*, tumble*, lost balance, fell off, or fell down	Narrative only
Mechanism	8. Wheeled/traffic event	bicycle, bike, skateboard, scooter, hoverboard, roller/inline skate, motorcycle, dirt bike, ATV/all-terrain, car, vehicle, traffic, moped, or golf cart	Narrative only
Mechanism	9. Other/unclear	No preceding rule matched	Narrative only
Activity	1. Basketball	basketball	Narrative + product labels
Activity	2. Soccer	soccer	Narrative + product labels
Activity	3. Football	football	Narrative + product labels
Activity	4. Volleyball	volleyball	Narrative + product labels
Activity	5. Baseball/softball	baseball or softball	Narrative + product labels
Activity	6. Gymnastics/ cheer/dance	gymnast*, cheer, dance, or ballet	Narrative + product labels
Activity	7. Track/running	track, running, jogging, cross country, or treadmill	Narrative + product labels
Activity	8. Wrestling/combat	wrestl*, martial art, karate, taekwondo, judo, or boxing	Narrative + product labels
Activity	9. Trampoline	trampoline	Narrative + product labels
Activity	10. Playground	playground, monkey bar, jungle gym, swing, see-saw, or seesaw	Narrative + product labels
Activity	11. Cycling	bicycle, bike, cycling, or mountain bike	Narrative + product labels
Activity	12. Skating/ skateboard/scooter	skateboard, scooter, hoverboard, roller/inline skate, or skating	Narrative + product labels
Activity	13. Snow/water/ equestrian	ski, snowboard, sled, ice skate, surf, swim, diving, boat, horse, equestrian, or water sport	Narrative + product labels
Activity	14. Traffic/transport	car, motor vehicle, vehicle, traffic, motorcycle, dirt bike, ATV/all-terrain, moped, or golf cart	Narrative + product labels
Activity	15. School nonsport	school, classroom, gym class, physical education, or P.E.	Narrative + product labels
Activity	16. Household/daily living	stair, step, bed, bunk, couch, sofa, chair, table, door, floor, home, house, shower, bathtub, or walking	Narrative + product labels
Activity	17. Other sport/ recreation	sport, practice, game, hockey, lacrosse, tennis, rugby, golf, bowling, frisbee, kickball, dodgeball, ultimate, fitness, exercise, or workout	Narrative + product labels
Activity	18. Other/unknown	No preceding rule matched	Narrative + product labels
Fracture subtype	1. Physeal/Salter-Harris/Tillaux/ triplane	salter, physeal, growth plate, Tillaux, or triplane	Narrative; index fracture only
Fracture subtype	2. Bi-/trimalleolar	bimalleolar, bi-malleolar, trimalleolar, or tri-malleolar	Narrative; index fracture only
Fracture subtype	3. Distal fibula/ lateral malleolus	distal fib*, lateral malleol*, or fibular	Narrative; index fracture only
Fracture subtype	4. Distal tibia/ medial malleolus	distal tib*, medial malleol*, or tibial	Narrative; index fracture only
Fracture subtype	5. Talus	talus or talar	Narrative; index fracture only
Fracture subtype	6. Avulsion	avulsion	Narrative; index fracture only
Fracture subtype	7. Unspecified/ other fracture	No preceding fracture-subtype rule matched	Narrative; index fracture only

Note. Rules were evaluated from top to bottom within each domain, and the first match was retained. Mechanism used narrative text only; numeric product codes never determined mechanism. Activity searched the narrative plus CPSC labels for every nonzero Product_1, Product_2, and Product_3 code. Common direct-label mappings included basketball (1205), football (1211), trampoline (1233), volleyball (1266), soccer (1267), wrestling (1270), gymnastics (1272), skateboards (1333), martial arts (3257), cheerleading (3254), dancing (3278), track and field (5030), softball (5034), bicycles (5040), and baseball (5041). The categories were not manually validated. The 142-character analysis evaluated sensitivity to narrative length, not classification validity.

denominator unless otherwise stated. Approximate standard errors were derived with a with-replacement Taylor linearization approach, treating year-by-CPSC stratum as strata and year-by-hospital identifier as primary sampling units. Student-t critical values based on observed design degrees of freedom were used for 95% confidence intervals (CIs). These are approximate, not official CPSC, variances because the filtered extract does not identify zero-case hospitals and official cross-year covariance information was unavailable. Consequently, CIs and p-values should be interpreted cautiously[14,17,18].

Estimates were flagged as potentially unstable when the unweighted count was < 20, the national estimate was < 1,200, or the coefficient of variation exceeded 33%, consistent with CPSC guidance[17]. Annual trends were explored with inverse-variance weighted least-squares regression of log national estimates on calendar year and heteroscedasticity-consistent HC3 standard errors. Slopes were exponentiated to annual percentage change (APC). Prespecified models included all years, all years excluding 2020, the pre-pandemic interval (2016-2019), and the recovery interval (2021-2025). Benjamini-Hochberg adjustment was applied within exploratory outcome families. All tests were two-sided with alpha = 0.05. Analyses used Python 3.12.14, NumPy 2.3.5, and pandas 2.2.3; workbook reconciliation used openpyxl 3.1.5, and Pillow 12.3.0 was used only for figure generation. Taylor variance, Student-t intervals, weighted least squares with HC3 covariance, and Benjamini-Hochberg adjustment were implemented in custom code.

Results

National burden and patient characteristics

Among 137,892 source records, 79,245 met the primary ankle definition (Figure 1). These cases represented 2,468,384 pediatric ankle injuries treated in United States EDs (95% CI, 2,283,776-2,652,992), averaging 246,838 per year. Children aged 10-14 years represented the largest share (44.5%; estimate, 1,099,649), followed by those aged 15-17 years (35.7%; estimate, 882,227), 5-9 years (14.7%), and 0-4 years (5.0%). Males accounted for 51.8% and females for 48.2%. Race was unknown or unstated for 31.2% of weighted visits. Among the 2019-2025 cohort, 13.5% were recorded as Hispanic (estimate, 212,937; 95% CI, 11.4%-15.8%), 58.1% as not Hispanic, and 28.5% as unknown or unstated (Table 2).

Most patients were treated and released (98.4%). The prespecified escalated-disposition composite included 1,001 sampled cases, representing 25,342 visits (1.03%; 95% CI, 0.90%-1.17%). No fatalities were recorded. Sports/recreation facilities were the most recorded injury location (35.5%; estimate, 876,684; 95% CI, 33.9%-37.2%), followed by school (17.5%) and home (15.3%); location was unknown in 27.5%. Fall (28.6%; estimate, 704,940; 95% CI, 28.0%-29.2%) and spring (27.7%) accounted for the largest seasonal shares (Table 3).

Diagnoses and age patterns

Sprains/strains were the predominant diagnosis (68.6%; estimate, 1,693,080), followed by other injury/pain (14.4%;

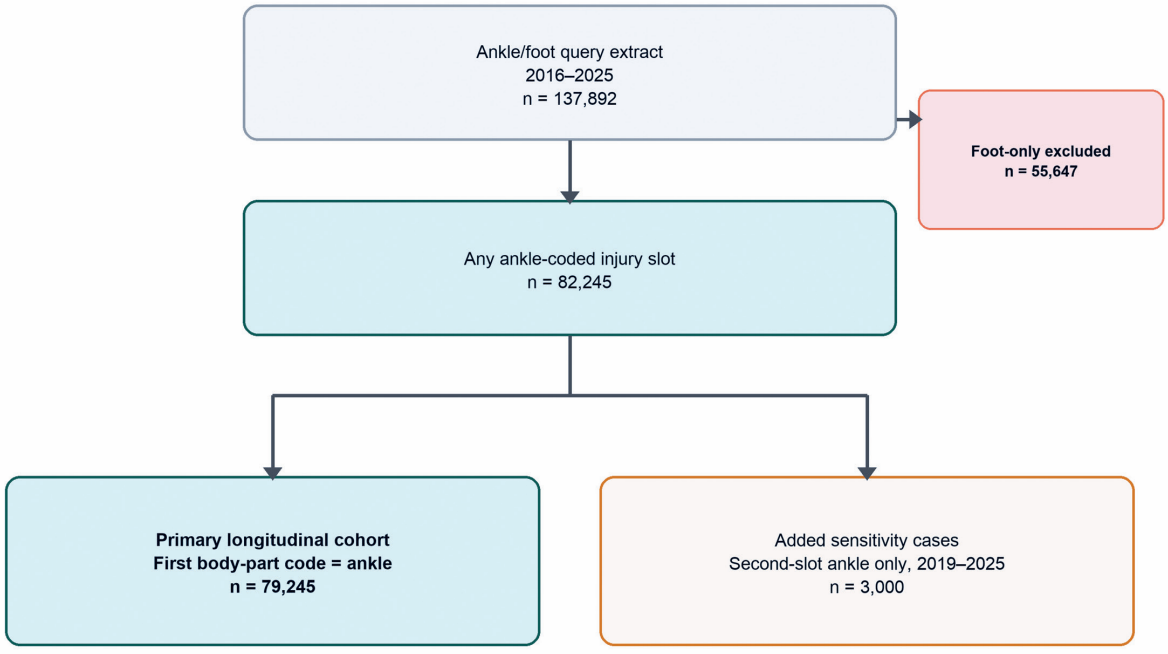

Figure 1. Cohort flow diagram for the 2016-2025 pediatric ankle injury analysis.
NEISS: National Electronic Injury Surveillance System.

Table 2. Patient demographics, ethnicity, and emergency department disposition

Section	Category	Raw n	Weighted estimate	Weighted %	95% CI, %	CV, %	Stability
Age group	0–4 years	4,207	123,417	5.0	4.6-5.4	6.8	Meets thresholds
Age group	5–9 years	12,731	363,091	14.7	14.1-15.3	5.2	Meets thresholds
Age group	10–14 years	36,014	1,099,649	44.5	44.0-45.1	3.8	Meets thresholds
Age group	15–17 years	26,293	882,227	35.7	34.9-36.6	3.3	Meets thresholds
Sex	Male	41,370	1,278,786	51.8	51.2-52.4	3.9	Meets thresholds
Sex	Female	37,869	1,189,336	48.2	47.6-48.8	3.8	Meets thresholds
Sex	Unknown	6	262	0.0	0.0-0.0	60.4	Unstable: n < 20; estimate < 1,200; CV > 33%
Race	White	31,548	1,155,065	46.8	42.8-50.9	3.9	Meets thresholds
Race	Black/African American	17,432	381,140	15.4	13.5-17.5	6.5	Meets thresholds
Race	Other	5,123	115,288	4.7	3.9-5.6	8.9	Meets thresholds
Race	Asian	1,420	30,358	1.2	1.0-1.5	11.0	Meets thresholds
Race	American Indian/ Alaska Native	252	13,337	0.5	0.4-0.7	15.0	Meets thresholds
Race	Native Hawaiian/ Pacific Islander	119	2,904	0.1	0.1-0.2	15.7	Meets thresholds
Race	Unknown/not stated	23,351	770,291	31.2	26.1-36.8	11.4	Meets thresholds
Hispanic ethnicity, 2019-2025	Yes	8,433	212,937	13.5	11.4-15.8	8.3	Meets thresholds
Hispanic ethnicity, 2019-2025	No	27,943	918,888	58.1	52.2-63.7	4.5	Meets thresholds
Hispanic ethnicity, 2019-2025	Unknown/not stated	15,422	450,927	28.5	22.2-35.7	15.4	Meets thresholds
ED disposition	Treated/released	77,649	2,428,303	98.4	98.2-98.5	3.8	Meets thresholds
ED disposition	Transferred	155	7,308	0.3	0.2-0.4	10.5	Meets thresholds
ED disposition	Admitted/hospitalized	803	16,684	0.7	0.6-0.8	8.7	Meets thresholds
ED disposition	Held for observation	43	1,351	0.1	0.0-0.1	26.9	Meets thresholds
ED disposition	Left without being seen	591	14,693	0.6	0.5-0.7	7.5	Meets thresholds
ED disposition	Fatality	0	0	0.0	0.0-0.0	—	Unstable: n < 20; estimate < 1,200
ED disposition	Unknown/not stated	4	46	0.0	0.0-0.0	71.8	Unstable: n < 20; estimate < 1,200; CV > 33%

Note. NEISS-weighted estimates and percentages use the primary cohort (weighted n = 2,468,384), except Hispanic ethnicity, which uses the 2019-2025 primary cohort (weighted n = 1,582,753). CIs and CVs use the approximate survey-variance method described in the manuscript. CPSC instability criteria are raw n < 20, national estimate < 1,200, or CV > 33%. Totals may differ slightly because of rounding.
CI: Confidence interval; CPSC: U.S. Consumer Product Safety Commission; CV: Coefficient of variation; ED: Emergency department; NEISS: National Electronic Injury Surveillance System.

Table 3. Injury location and treatment season

Section	Category	Raw n	Weighted estimate	Weighted % (95% CI)	Stability
Location	Sports/recreation	30,373	876,684	35.5% (33.9%-37.2%)	Meets thresholds
Location	Unknown	23,451	678,064	27.5% (25.5%-29.5%)	Meets thresholds
Location	School	12,211	431,227	17.5% (16.6%-18.4%)	Meets thresholds
Location	Home	10,555	378,626	15.3% (14.5%-16.2%)	Meets thresholds
Location	Public	1,721	65,506	2.7% (2.4%-3.0%)	Meets thresholds
Location	Street	907	37,164	1.5% (1.3%-1.7%)	Meets thresholds
Location	Farm	19	909	0.04% (0.02%-0.06%)	Unstable: n < 20; estimate < 1,200
Location	Mobile home	3	113	< 0.01% (<0.01%-0.02%)	Unstable: n < 20; estimate < 1,200; CV > 33%
Location	Industrial	5	89	< 0.01% (<0.01%-0.01%)	Unstable: n < 20; estimate < 1,200; CV > 33%
Location	Apartment	0	0	0.00% (0.00%-0.00%)	Unstable: n < 20; estimate < 1,200
Season	Fall	22,688	704,940	28.6% (28.0%-29.2%)	Meets thresholds
Season	Spring	22,294	684,363	27.7% (27.1%-28.4%)	Meets thresholds
Season	Winter	17,375	556,631	22.6% (21.9%-23.2%)	Meets thresholds
Season	Summer	16,888	522,450	21.2% (20.7%-21.7%)	Meets thresholds

Note. Percentages use the full primary cohort (weighted n = 2,468,384). CIs use the approximate survey-variance method described in the manuscript. CPSC instability criteria are raw n < 20, national estimate < 1,200, or CV > 33%. Location was unknown for 27.5% of weighted visits.
CI: Confidence interval; CPSC: U.S. Consumer Product Safety Commission; CV: Coefficient of variation.

estimate, 354,526) and fractures (11.6%; estimate, 286,159) (Table 4). Contusions/abrasions accounted for 3.2%, lacerations 1.7%, dislocations 0.15%, and other rare diagnoses 0.42%. The sprain/strain share increased across age groups, from 43.0% among children aged 0-4 years to 74.2% among those aged 15-17 years. Fractures comprised 15.5% of injuries among children aged 0-4 years and 10.1% among adolescents aged 15-17 years (Table 5; Figure 2). Within the index-diagnosis fracture cohort, 78.74% were unspecified/other by narrative. Distal fibula/lateral malleolus (5.80%; 95% CI, 4.94%-6.80%) and physeal/Salter-Harris/Tillaux/triplane (5.59%; 95% CI, 4.74%-6.59%) were the most frequent specific rule-based subtypes (Table 6).

Table 4. Diagnoses and exploratory rule-based injury mechanisms

Section	Category	Raw n	Weighted estimate	Weighted %	95% CI, %	CV, %	Stability
Diagnosis	Sprain/strain	54,517	1,693,080	68.6	67.1-70.0	4.0	Meets thresholds
Diagnosis	Fracture	9,944	286,159	11.6	11.1-12.1	4.0	Meets thresholds
Diagnosis	Other injury/pain	10,483	354,526	14.4	13.0-15.8	6.2	Meets thresholds
Diagnosis	Contusion/abrasion	2,521	78,003	3.2	3.0-3.4	4.7	Meets thresholds
Diagnosis	Laceration	1,321	42,611	1.7	1.6-1.9	6.9	Meets thresholds
Diagnosis	Dislocation	125	3,622	0.1	0.1-0.2	12.6	Meets thresholds
Diagnosis	Other rare diagnosis	334	10,384	0.4	0.4-0.5	8.5	Meets thresholds
Exploratory rule-based mechanism	Noncontact rotation/misstep	29,051	865,623	35.1	33.5-36.7	4.3	Meets thresholds
Exploratory rule-based mechanism	Jump/landing	5,787	177,119	7.2	6.8-7.6	4.0	Meets thresholds
Exploratory rule-based mechanism	Fall	15,800	477,331	19.3	18.3-20.4	5.7	Meets thresholds
Exploratory rule-based mechanism	Contact/collision/direct blow	3,599	99,592	4.0	3.7-4.4	4.0	Meets thresholds
Exploratory rule-based mechanism	Crush/entrapment/struck by object	2,036	60,902	2.5	2.3-2.7	5.3	Meets thresholds
Exploratory rule-based mechanism	Wheeled/traffic event	941	36,303	1.5	1.3-1.6	5.1	Meets thresholds
Exploratory rule-based mechanism	Penetrating/burn/bite/other hazard	1,088	32,420	1.3	1.2-1.4	5.8	Meets thresholds
Exploratory rule-based mechanism	Overuse/atraumatic	52	1,434	0.1	0.0-0.1	21.1	Meets thresholds
Exploratory rule-based mechanism	Other/unclear	20,891	717,661	29.1	27.4-30.8	4.7	Meets thresholds

Note. Percentages use the primary cohort. Mechanisms were assigned by the prespecified narrative-only hierarchy in Table 1. The categories were not manually validated, are hypothesis-generating, and do not establish causal mechanisms; 29.1% remained other/unclear. CPSC instability criteria are raw n < 20, national estimate < 1,200, or CV > 33%.
CI: Confidence interval; CPSC: U.S. Consumer Product Safety Commission; CV: Coefficient of variation; NEISS: National Electronic Injury Surveillance System.

Table 5. Leading diagnoses by age group

Age group	Diagnosis	Raw n	Weighted estimate	Within-age %	Stability
0-4 years	Sprain/strain	1,790	53,063	43.0	Meets thresholds
0-4 years	Fracture	736	19,174	15.5	Meets thresholds
0-4 years	Other injury/pain	921	28,461	23.1	Meets thresholds
5-9 years	Sprain/strain	7,725	217,544	59.9	Meets thresholds
5-9 years	Fracture	1,726	46,779	12.9	Meets thresholds
5-9 years	Other injury/pain	2,045	63,323	17.4	Meets thresholds
10-14 years	Sprain/strain	25,302	767,861	69.8	Meets thresholds
10-14 years	Fracture	4,720	131,107	11.9	Meets thresholds
10-14 years	Other injury/pain	4,522	153,139	13.9	Meets thresholds
15-17 years	Sprain/strain	19,700	654,611	74.2	Meets thresholds
15-17 years	Fracture	2,762	89,098	10.1	Meets thresholds
15-17 years	Other injury/pain	2,995	109,602	12.4	Meets thresholds

Note. The three leading diagnosis groups are displayed for each age group. Percentages are calculated within age group; therefore, displayed rows do not sum to 100%. Estimates are flagged when raw n < 20, the national estimate is < 1,200, or CV > 33%, consistent with CPSC guidance.
CPSC: U.S. Consumer Product Safety Commission; CV: Coefficient of variation; NEISS: National Electronic Injury Surveillance System.

Mechanisms and activities

The prespecified narrative-only rules classified 35.1% of all visits as noncontact rotation/misstep (estimate, 865,623), 19.3% as fall (estimate, 477,331), 7.2% as jump/landing, and 4.0% as contact/collision/direct blow (Table 4; Figure 3). Other/unclear narratives constituted 29.1%. These percentages describe outputs of an unvalidated rule set and should not be interpreted as verified causal mechanisms. Restriction to the first 142 narrative characters preserved 99.0% weighted agreement with the full-text rule output; this assessed sensitivity to narrative length, not classification validity.

The exploratory combined narrative and product-label rules classified basketball as the most frequent activity context (18.4%; estimate, 455,069), followed by household/daily living (15.2%), soccer (8.2%), football (7.6%), trampoline use (6.7%), and track/running (5.8%) (Table 7; Figure 4). These values describe ED-treated counts under an unvalidated rule set and are not participation-adjusted risks. From 2019 through 2025, any companion body part was recorded for an estimated 134,925 visits (8.5%); the most frequent were foot (56,768; 3.6%), ankle (27,446; 1.7%), knee (14,029; 0.9%), and lower leg (13,338; 0.8%) (Table 7).

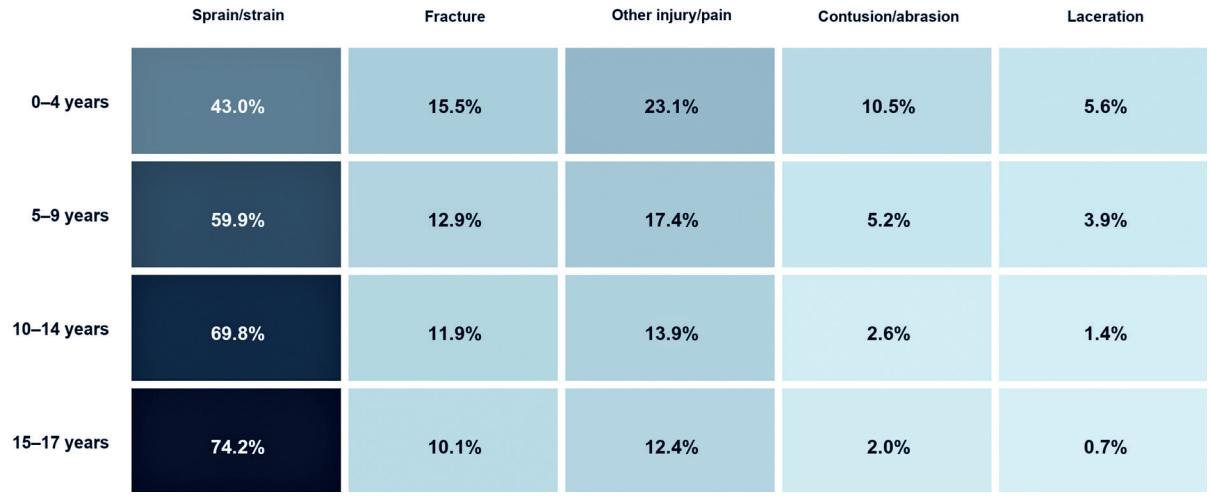

Figure 2. Weighted diagnosis distribution by age group.
Percentages are calculated within age group.

Table 6. Exploratory rule-based fracture subtypes within the index-diagnosis fracture cohort, overall and by age group

Fracture subtype	Overall, raw n; estimate (within-cohort %)	0-4 years	5-9 years	10-14 years	15-17 years
Physeal/Salter-Harris/ Tillaux/triplane	498; 16,008 (5.59%; 95% CI, 4.74%-6.59%)	40; 1,240 (6.47%)	84; 2,796 (5.98%)	334; 10,748 (8.20%)	40; 1,224 (1.37%)
Bi-/trimalleolar	110; 4,064 (1.42%; 95% CI, 1.10%-1.84%)	1; 5 (0.03%)*	5; 191 (0.41%)*	48; 1,744 (1.33%)	56; 2,125 (2.38%)
Distal fibula/ lateral malleolus	465; 16,587 (5.80%; 95% CI, 4.94%-6.80%)	24; 666 (3.47%)*	86; 2,280 (4.87%)	194; 6,933 (5.29%)	161; 6,709 (7.53%)
Distal tibia/ medial malleolus	377; 9,187 (3.21%; 95% CI, 2.62%-3.93%)	87; 1,265 (6.60%)	76; 2,069 (4.42%)	146; 3,777 (2.88%)	68; 2,076 (2.33%)
Talus	163; 5,140 (1.80%; 95% CI, 1.38%-2.33%)	4; 23 (0.12%)*	14; 366 (0.78%)*	66; 1,991 (1.52%)	79; 2,760 (3.10%)
Avulsion	358; 9,864 (3.45%; 95% CI, 2.89%-4.10%)	7; 139 (0.72%)*	95; 2,478 (5.30%)	128; 4,092 (3.12%)	128; 3,155 (3.54%)
Unspecified/ other fracture	7,973; 225,309 (78.74%; 95% CI, 76.35%-80.94%)	573; 15,836 (82.59%)	1,366; 36,600 (78.24%)	3,804; 101,823 (77.66%)	2,230; 71,050 (79.74%)
Total index-diagnosis fractures	9,944; 286,159 (100.00%)	736; 19,174 (100.00%)	1,726; 46,779 (100.00%)	4,720; 131,107 (100.00%)	2,762; 89,098 (100.00%)

Note. Cells report raw n; weighted estimate (within-age percentage), except the overall column, which also reports the approximate Taylor 95% CI for the percentage. The cohort is restricted to the 9,944 cases whose index diagnosis was fracture; it therefore reconciles exactly with the fracture total in Table 4. Subtypes were assigned from narrative text by the ordered rules in Table 1 and were not manually validated. *Potentially unstable under CPSC criteria because raw n < 20 or the national estimate was < 1,200.
CI: Confidence interval; CPSC: U.S. Consumer Product Safety Commission.

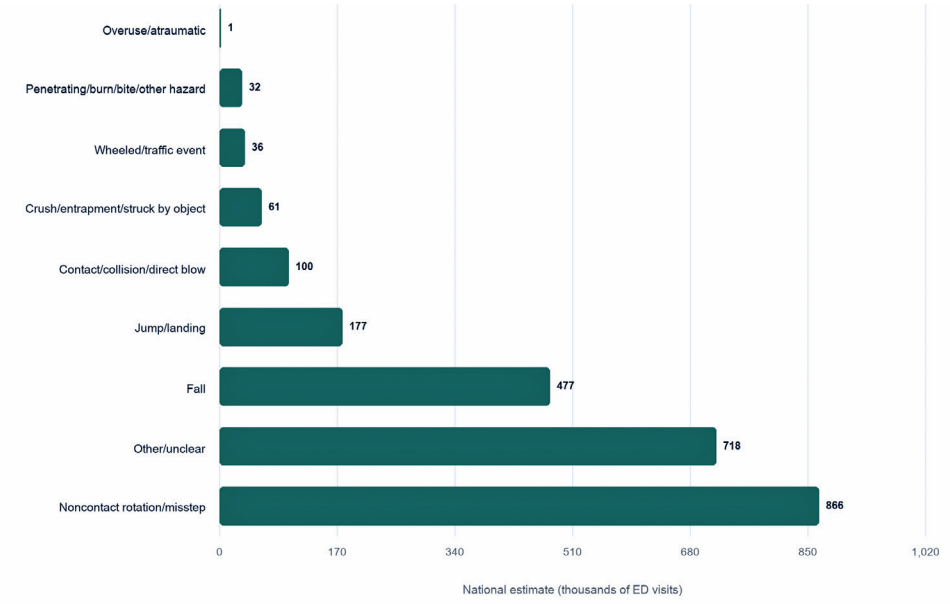

Figure 3. Weighted distribution of exploratory, rule-based narrative classifications of injury mechanism.
Categories were not manually validated and are presented as hypothesis-generating descriptive groupings; they do not establish causation.
ED: Emergency department.

Table 7. Exploratory activity contexts and selected associated findings

Section	Category	Raw n	Weighted estimate	Weighted %	95% CI, %	CV, %	Stability
Exploratory activity context	Basketball	14,513	455,069	18.4	17.8-19.1	3.6	Meets thresholds
Exploratory activity context	Household/ daily living	12,445	375,881	15.2	14.8-15.7	3.8	Meets thresholds
Exploratory activity context	Other/unknown	8,544	264,236	10.7	10.3-11.1	4.1	Meets thresholds
Exploratory activity context	Soccer	7,254	203,404	8.2	7.8-8.7	5.4	Meets thresholds
Exploratory activity context	Football	6,061	187,571	7.6	7.3-8.0	4.0	Meets thresholds
Exploratory activity context	Trampoline	5,158	164,359	6.7	6.2-7.1	5.7	Meets thresholds
Exploratory activity context	Track/running	4,332	143,267	5.8	5.4-6.2	6.3	Meets thresholds
Exploratory activity context	School nonsport	4,228	135,484	5.5	5.2-5.8	4.6	Meets thresholds
Exploratory activity context	Skating/skateboard/ scooter	3,474	105,124	4.3	4.0-4.5	4.8	Meets thresholds
Exploratory activity context	Cycling	2,553	81,753	3.3	3.1-3.5	5.6	Meets thresholds
Exploratory activity context	Volleyball	2,426	80,788	3.3	3.1-3.5	4.5	Meets thresholds
Exploratory activity context	Baseball/softball	2,138	77,374	3.1	2.9-3.3	4.7	Meets thresholds
Prespecified escalated disposition	Transferred, admitted, or observed	1,001	25,342	1.0	0.9-1.2	6.8	Meets thresholds
Recorded companion body part, 2019+	Foot	1,448	56,768	3.6	3.1-4.1	6.9	Meets thresholds
Recorded companion body part, 2019+	Ankle	884	27,446	1.7	1.4-2.2	11.1	Meets thresholds
Recorded companion body part, 2019+	Knee	406	14,029	0.9	0.8-1.0	7.4	Meets thresholds
Recorded companion body part, 2019+	Lower Leg	438	13,338	0.8	0.7-1.0	7.9	Meets thresholds
Recorded companion body part, 2019+	Wrist	88	3,016	0.2	0.1-0.3	14.6	Meets thresholds
Recorded companion body part, 2019+	Lower Trunk	82	2,802	0.2	0.1-0.2	15.3	Meets thresholds
Recorded companion body part, 2019+	Head	84	2,740	0.2	0.1-0.2	14.5	Meets thresholds
Recorded companion body part, 2019+	Elbow	60	1,941	0.1	0.1-0.2	17.6	Meets thresholds

Note. Activity contexts were assigned by the prespecified first-match hierarchy in Table 1 using narrative text and CPSC labels for all nonzero product-code fields. The categories were not manually validated and describe ED-treated burden rather than participation-adjusted risk. Activity and escalated-disposition percentages use the full primary cohort. Companion body-part percentages use the 2019-2025 primary cohort (weighted n = 1,582,753), when companion fields were available. Escalated disposition comprises transfer, admission/hospitalization, or observation. Estimates are flagged when raw n < 20, the national estimate is < 1,200, or CV > 33%, consistent with CPSC guidance.
CI: Confidence interval; CPSC: U.S. Consumer Product Safety Commission; CV: Coefficient of variation; NEISS: National Electronic Injury Surveillance System.

Temporal trends and sensitivity analyses

Annual estimates peaked in 2016 at 306,634 and were lowest in 2020 at 145,027 (Table 8; Figure 5). The estimate declined 44.1% from 2019 to 2020, then increased 81.9% from 2020 to 2025; the 2025 estimate was 1.7% above the 2019 estimate. The four prespecified overall models yielded APCs of -1.82% for 2016-2025 (95% CI, -5.95% to 2.50%; p = 0.354), -2.04% after excluding 2020 (95% CI, -4.78% to 0.77%; p = 0.129), -5.70% for 2016-2019 (95% CI, -15.33% to 5.04%; p = 0.144), and 7.48% for 2021-2025 (95% CI, -0.48% to 16.09%; p = 0.059). In exploratory diagnosis models excluding 2020, sprain/strain visits declined by 3.87% annually (95% CI, -5.99% to -1.70%; unadjusted p = 0.004; Benjamini-Hochberg-adjusted p = 0.021); no other diagnosis or mechanism trend survived within-family adjustment. Estimates crossing 2024 should also be interpreted considering the NEISS sample transition.

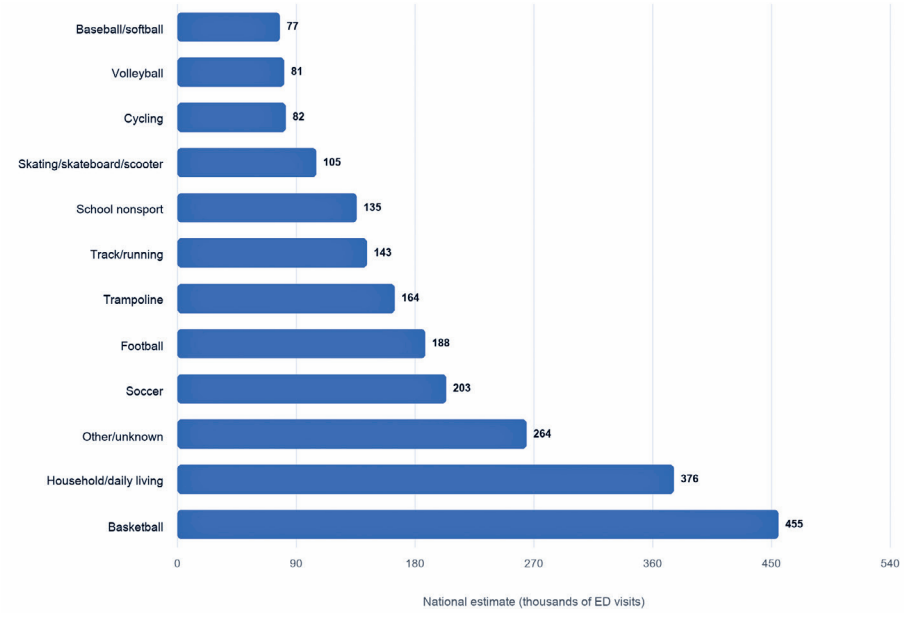

Figure 4. Leading weighted exploratory activity contexts derived from narrative and product-label text among ED-treated pediatric ankle injuries.

Values describe burden under an unvalidated rule set, not exposure-adjusted risk.

ED: Emergency department.

Table 8. Annual national estimates and any-injury-slot sensitivity analysis

Year	Primary raw n	Primary estimate (95% CI)	Primary CV, %	Primary stability	Any-slot raw n	Any-slot estimate	Difference, %
2016	9,152	306,634 (245,325-367,943)	10.0	Meets thresholds	—	—	—
2017	9,680	304,171 (246,319-362,023)	9.6	Meets thresholds	—	—	—
2018	8,615	274,826 (206,432-343,220)	12.5	Meets thresholds	—	—	—
2019	8,427	259,369 (188,217-330,521)	13.8	Meets thresholds	8,853	271,514	4.7
2020	5,221	145,027 (104,348-185,707)	14.1	Meets thresholds	5,586	155,106	6.9
2021	7,145	196,044 (137,676-254,412)	14.9	Meets thresholds	7,545	206,447	5.3
2022	7,211	226,656 (156,826-296,487)	15.5	Meets thresholds	7,586	239,355	5.6
2023	7,403	230,128 (170,009-290,247)	13.1	Meets thresholds	7,840	244,271	6.1
2024	7,978	261,687 (215,177-308,197)	8.9	Meets thresholds	8,414	276,321	5.6
2025	8,413	263,841 (213,733-313,949)	9.5	Meets thresholds	8,974	283,131	7.3

Note. The primary cohort required ankle (body-part code 37) in the first injury slot. A second injury slot became available in 2019; any-slot values are therefore shown only for 2019-2025. Difference (%) = (any-slot estimate-primary estimate)/primary estimate x 100. The 2019-2025 primary total is calculated from unrounded annual estimates (1,582,752.637, reported as 1,582,753); independently rounded annual estimates displayed in the table sum to 1,582,752. Estimates crossing the 2023-2024 boundary should be interpreted cautiously because redesigned NEISS sample weights were used beginning in 2024. CPSC instability criteria are raw n < 20, national estimate < 1,200, or CV > 33%.

CI: Confidence interval; CPSC: U.S. Consumer Product Safety Commission; CV: Coefficient of variation; NEISS: National Electronic Injury Surveillance System.

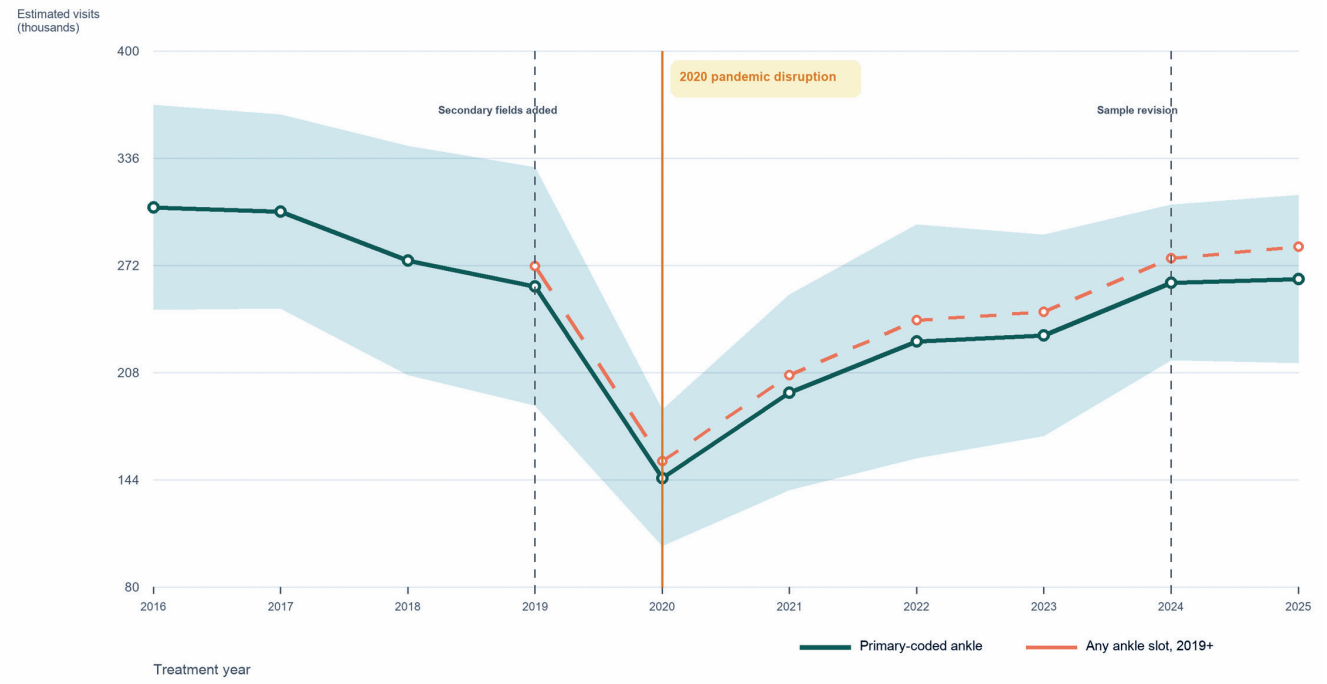

Figure 5. Annual national estimates of ED-treated pediatric ankle injuries, 2016-2025. The any-slot series begins in 2019, when the secondary injury field became available. Vertical markers denote the 2019 addition of secondary injury fields (gray dashed), the 2020 pandemic disruption (orange solid), and the 2024 NEISS sample transition (gray dashed); the shaded band is the approximate 95% CI. Estimates spanning the 2023-2024 boundary should be interpreted cautiously because redesigned NEISS sample weights were used beginning in 2024.

ED: Emergency department; CI: Confidence interval; NEISS: National Electronic Injury Surveillance System.

From 2019 through 2025, the primary-slot cohort represented 1,582,753 visits. This total was calculated from unrounded annual estimates; independently rounded annual values displayed in Table 8 sum to 1,582,752. Including ankle code 37 in either injury slot added 3,000 sampled cases and 93,392 estimated visits, increasing the estimate by 5.9% to 1,676,145. Annual increases from the expanded definition ranged from 4.7% to 7.3%.

Discussion

This nationally representative ED analysis described approximately 2.47 million pediatric ankle injury visits over 10 years, with four-fifths occurring among patients aged 10-17 years. Sprains/strains accounted for more than two-thirds of the burden, the sex distribution was nearly equal, and approximately 1% of visits resulted in transfer, admission, or observation. The rule-based outputs most often assigned rotation/misstep as the mechanism and basketball as the activity, but these unvalidated classifications are secondary, hypothesis-generating descriptions rather than confirmed causes or comparative risks. The pronounced 2020 decline was followed by recovery to slightly above the 2019 estimate by 2025.

The age and diagnostic patterns accord with prior study. Waterman et al.[2] found peak ankle-sprain incidence among people aged 15-19 years, while Wiersma et al.[3] reported that sprains/strains exceeded 80% of ankle injuries in school athletic-training settings but that fractures were proportionally more common in EDs. Our fracture proportion of 11.6% is consistent with the greater acuity represented in ED surveillance. In our data, the increasing sprain share with age was accompanied by a larger relative fracture burden among younger children; this pattern should be interpreted descriptively because NEISS lacks exposure and skeletal-maturity data.

The frequency with which the exploratory rules assigned basketball is consistent with prior national and sport-specific surveillance[2,8-11]. Soccer and football were also commonly assigned, consistent with broader NEISS surveillance of pediatric sports injuries[19]. However, the present data contain neither participation denominators nor manual validation of activity and mechanism categories. Accordingly, differences in classified counts may reflect exposure volume, documentation, product coding, or rule performance and cannot identify which activities are riskier, which mechanisms caused injury, or which interventions would be effective.

The 44.1% reduction in 2020 should be interpreted as a change in ED-treated burden rather than evidence of reduced biological susceptibility. Pandemic-related restrictions altered sport, school, recreation, healthcare seeking, and exposure opportunities. National pediatric fracture and basketball-injury studies similarly documented large 2020 reductions followed by recovery[10,20,21]. None of the four prespecified overall trend models reached $p < 0.05$, and a single linear trend incompletely represents the pandemic disruption. The exploratory decline in sprain/strain estimates after excluding 2020 warrants replication because diagnostic coding, ED utilization, activity exposure, and the 2024 sample transition may affect longitudinal comparisons.

The second-slot analysis provides an additional methodological finding. Inclusion of ankle injuries recorded in either slot increased the 2019-2025 estimate by 5.9%. Thus, studies using post-2019 NEISS data should state explicitly whether the first injury slot or any injury slot defines the cohort. For decade-spanning comparisons, the primary-slot definition offers temporal consistency, whereas any-slot estimates better describe multi-injury capture after 2019.

Limitations

This study has limitations inherent to NEISS. First, it captures injuries treated in sampled EDs and excludes urgent-care, clinic setting, athletic-training, and untreated injuries; results therefore describe ED burden, not population or sport-specific incidence[3,18]. Second, weights produce national estimates, but the variance method was approximate because zero-case hospitals and official cross-year covariance were unavailable. Third, exposure denominators were unavailable, so activity counts cannot be interpreted as comparative injury risk. Fourth, diagnoses and locations depend on ED documentation and CPSC coding; clinical details such as imaging, ligament grade, treatment, recurrence, and outcomes are absent. Fifth, race was frequently unrecorded, and Hispanic ethnicity, companion injury, and second injury-slot variables were not consistently available before 2019. Sixth, rule-based mechanisms, activity contexts, laterality, and fracture subtypes were not manually validated; 29.1% of mechanisms and most fracture subtypes remained unclear. Agreement after truncation to 142 characters addresses narrative length but does not establish validity. Finally, the NEISS hospital sample and associated weights changed in 2024. CPSC resampled NEISS in 2021, used overlapping old and redesigned samples in 2024, and used the redesigned sample for national estimates beginning in 2024[22]. CPSC applied overlap-specific backcasting to its national historical series, but equivalent injury-specific backcast factors were not applied here. Comparisons crossing 2023-2024 may therefore reflect both true changes in ED presentations and effects of the sample transition; we treat 2024 as a comparability boundary and interpret trends spanning it cautiously.

Conclusion

Pediatric ankle injuries accounted for an estimated 2.47 million United States ED visits from 2016 to 2025. Burden was concentrated among adolescents, sprains/strains predominated, and most patients were treated and released. Annual visits fell sharply in 2020 and subsequently recovered, while none of the four prespecified overall trend models reached statistical significance. The rule-based mechanism, activity, and fracture-subtype findings are exploratory and require independent validation. This descriptive study does not establish causal mechanisms, comparative activity risk, or the effectiveness of preventive interventions.

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